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ORIGINAL ARTICLES.

WILLIAM FERREL.

One of the most interesting books of our time is the life of James Clerk Maxwell. It is so because the great attainments of the *professor* in science serve as an effective back-ground for the very attractive personality of the man himself.

It is not given to all men to follow even, where Maxwell led. Indeed, the number who can read understandingly his scientific papers, appreciating thoroughly their value, is very limited. That this is so, emphasizes the fact that it is not altogether upon these contributions to science, that the secret of our great interest in the man depends. A man may be great to the profession because of his work. To the lay mind, the charm which most interests is the degree of intimacy it is able to establish between itself and greatness. We always are pleased and ready to make the personal acquaintance of greatness; and the character of the distinguished one is doubly attractive, when in this intimacy with common minds, it compels not less affection than admiration from them. The character of William Ferrel is very much alike to that of Maxwell.

Gentleness of disposition and evenness of character are to be found in the lives of most of those who are pre-eminent in science. Newton's comparison of himself to a boy on the seashore, is only the exemplification of the modesty and self-depre-

ciation that quicken in minds intent on knowledge, almost with the first aspiration. And herein, no doubt, is the reason why, with so many men of science, the affection which their lives called forth remains when the admiration which their work elicited has subsided. The rule is so general that an exception serves but as an illustration. The life of Francis Bacon, with all its splendors, was a failure; because he did not display in his dealings with men the sincerity and integrity that are so strongly insisted upon, and are so essential in the experimental sciences. His manner of meeting the world, the scientific minds of our time know not, nor desire to know. It is foreign to their nature to win by yielding, and they wait rather than adapt themselves to the moment. Their ideal life is one marked by direct and steady, even if slow, progression, and not one in which progress, "like that of a tacking ship, is the resultant of opposite divergencies from the straight path."*

The trait of character most marked in Professor Ferrel, is just this indifference to personal position, and an extreme diffidence. To better understand these traits of character, it is necessary to know something of the circumstances of birth and surroundings, and their probable influences. These, it would seem, were not calculated to help or encourage him in early life, in following the natural bent of his mind. Some men are spurred on to fame, by the presence and admiration of friends. The opportunities seem to but await the man; and his success is none the less creditable, even if under such stimulus. But in equity, the more credit must be adjudged the man, successful under drawbacks, than to another reaching an equally exalted station, but whose whole career had been favored by all that weighed against his competitor. This must be remembered in making, not improperly, I think, a comparison between two men, Maxwell and Ferrel, very much alike in disposition and bearing, working in fields not far removed, but under somewhat differing circumstances of life. Maxwell was the brightest intellect that ever paused to spend itself on problems of light and electricity. Ferrel in a less pronounced career, with care

*Huxley, "Science and the Bishops," *Nineteenth Century*, October, 1887.

and in quiet, built a science, and lifted meteorology from a mass of observations and description, with a few self-appearing general laws, to an exactitude requiring the most refined methods of mathematical discussion. Maxwell's character, like his work, is beyond criticism. His life was without flaw, and we love his memory. Yet, "adverse circumstance," in Maxwell's career, was a factor altogether unknown. The honors which he bore so well, came to him, in both time and degree, as they should. With Ferrel, in this relation, it has been very different, and his lot has been the usual one of a long, wearying struggle against difficulties. His explanation of the effects of centrifugal force, and his theory applying it to the general atmospheric circulation, were in print many years before proper recognition of their importance came. The first of his papers bearing directly upon meteorology, was published as early as 1856. It was in the form of essays, contributed to the *Nashville Journal of Medicine and Surgery*. The intention of the author was to show a possible explanation, in the deflective effects due to the earth's rotation, of the general circulation of the atmosphere. The diminution of atmospheric pressure at the poles and equator, and the increase at the tropics; the gyratory motion of storms and the deflected courses of ocean currents, Ferrel sought to explain, as the necessary consequences of forces which have their origin in the rotation of the earth on its axis. This line of reasoning, furthermore, accounted for, without straining of facts, the prevailing wind directions in the middle latitudes. In 1858–60, the ideas advanced in the earlier paper, which, in addition, had been printed in small pamphlet form, were treated of in a more extended paper, and contributed to *Runkle's Mathematical Monthly*, and also reprinted in pamphlet form shortly after. This paper was again reprinted under the title, "Motions of Fluids and Solids on the Earth's Surface," as one of the Professional Papers of the Signal Service.* In this paper Professor Ferrel proposes a complete analytical investigation of the general motions of fluids surrounding the earth, as determined by given forces arising from the combined effects of attraction,

* Professional Papers, No. VIII. Reprinted with notes, by Frank Waldo.

and the rotation of the earth on its axis. The first half of the paper is occupied mainly with the discussion of the general equations of motion relative to the earth's surface. It is necessary to have these equations set forth clearly and understood at the outset, as they are the working tools of the author in his solutions of the various problems mentioned above. The more important of the results obtained by these methods, and given in detail, in the latter half of the paper, are:

1st. A fluid mass surrounding the earth, and assuming that the resistance to its motion, offered by the earth's surface, is not considerable, will have a figure, the surface of which is slightly depressed at the equator, bulges out at about the latitudes of 35°, and is depressed at the poles much more than at the equator.

2nd. Between the parallels of 35° and the poles, the motion of this fluid will be easterly, while between these parallels and the equator, this motion will be westerly. This gives an explanation for the trade winds, altogether different from the theory ordinarily given, in which it is assumed that the tendency of the lineal velocity of the air, to remain the same, when moving to and from the equator, results in these winds.

3rd. A body free to move on the surface of the earth experiences a force, arising from the earth's rotation, tending to give it a right-handed deflection in the northern hemisphere, and left-handed in the southern.

The general laws as stated above received considerable attention and discussion; in France, soon after publication, particularly at different sittings of the Academy. In this country and England they seem to have passed without comment until recent years, when more attention has been directed to the study of meteorology. They are now recognized by all prominent writers as fundamental propositions in the study of meteorology. The direct outcome of the application of these methods of reasoning to the general motions and pressure of the atmosphere, is, in brief, the recognition of deflective effects in general movements, and in particular or storm movements of the atmosphere; the determination of the places on the earth's surface where east and west motion of the atmosphere is destroyed, or

in other words, the regions of calm belts, the maximum heights of atmosphere, near the parallels of 30°, and the general circulation of the winds. These last may be remembered, more easily, by the aid of a comparison made near the end of the third section of the paper.* "The general motions of the atmosphere in each hemisphere form a grand cyclone, having the pole for its centre and the equatorial calm belt for its limit." The denser portion of the atmosphere, however, is in the middle, and we have descending currents at the pole or center of the cyclone, instead of the ascending currents so familiar in the ordinary cyclone where the more rare portion of the atmosphere is in the center.

Incidentally, the explanation of the destructive elements in a tornado follows from our author's theory, and it gives the only explanation, accounting for the peculiar features of storms of this class.† The center of a tornado may become nearly a vacuum under the influence of centrifugal force developed by the gyratory motion of the atmosphere. Similarly with water-spouts. The explanation of their origin and energy follows, as a matter of course. "A water-spout is generally first formed above, in the form of a cloud, shaped like a funnel or inverted cone. As there is less resistance to the motions in the upper strata than near the earth's surface, the rapid gyratory motion commences there first. The cold air above is drawn down, and coming in contact with the warm and moist atmosphere ascending in the middle of the tornado, condenses the vapor and forms the funnel-shaped cloud. As the gyratory motion becomes more violent, it gradually overcomes the resistances nearer the surface of the sea, and the vertex of the funnel-shaped cloud gradually descends lower, and the imperfect vacuum of the center of the tornado reaches the sea, up which the water has a tendency to ascend to a certain height, and thence the rapidly ascending spiral motion of the atmosphere carries the spray upward until it joins the cloud above, when the water spout is complete." ‡

* Professional Papers of the Signal Service, No. VIII, Part I, page 40.

† For an exposition of Ferrel's Theory of Tornadoes, the reader is referred to Davis's "Whirlwinds, Cyclones and Tornadoes," p. 82, *et seq.*

‡ P. 40, *loc. cit.*

In 1856, Professor Ferrel wrote an article on "The Problem of the Tides," for Gould's *Astronomical Journal* (IV, 173), and in 1858 he published in the same journal (V. 97, 113), "Influence of Earth's Rotation on the Motion of Bodies."

Professor Ferrel's mathematical papers on the motions of the ocean are of equal significance with those on the motions of the atmosphere. The familiar "Essay on the Winds and Currents of the Ocean"* had its origin in the following way: In conversation one day with his friend, Dr. W. K. Bowling,† Ferrel mentioned his having read Maury's "Physical Geography of the Sea," and his disagreeing with him on many points. Bowling desired him "to pitch into him," as he expressed it, and furnish a review of the book for the *Medical Journal.* Ferrel declined to do so, but at length consented to furnish an essay on certain subjects treated in the book, and *notice Maury's views a little in an incidental way.* The essay is the first of six, which have since been reprinted in Professional Paper No. XII of the Signal Service. They may be found also:

"Essay on the Winds and Currents of the Ocean."—*Nashville Journal of Medicine,* 1856.

"Motions of Fluids and Solids Relative to the Earth's Surface."—*American Journal of Science.* 1861.

"Cause of Low Barometer in the Polar Regions and in the Central Part of Cyclones."—*Nature,* July, 1871.

"Relation Between the Barometric Gradient and Velocity of the Wind."—*American Journal of Science,* November, 1874.

"Meteorological Researches. Part II. Cyclones, Tornadoes and Water-Spouts."—*American Journal of Science,* July, 1881.

The last paper may be found in full, as Appendix 10 to the Coast and Geodetic Survey Report for 1878.

These essays, together, make the most admirable contribution to the popular knowledge of meteorology yet given by any one mind. Unlike his other essays, they do not require, on the part of the reader, a very high mathematical knowledge. The type

* No. I. of the "Popular Essays."

† Professor then (1854) in the Medical College at Nashville, Tenn., Editor of the *Nashville Medical Journal,* and always a warm friend of Professor Ferrel.

of a purely professional paper is the one entitled, "Researches on the Temperature of the Atmosphere and the Earth's Surface." * This discusses the subjects of solar radiation, actinometry and general temperature distribution, and is not adapted for general reading. Professor Ferrel's latest contribution to meteorology—"Recent Advances in Meteorology" †—is the best summary of the principles and results of meteorology in existence. There is no attempt at description of instruments, but there is the fullest and best discussion of the problems of meteorology and the different questions of research that can be found anywhere. From 1882 to 1886, Professor Ferrel engaged in the work of the Signal Office, reserving, however, a part of his time for the Coast and Geodetic Survey, with which he had for many years been connected. It was in 1857 that he first became interested in the American Ephemeris and Nautical Almanac, receiving from Professor Winlock, the then Superintendent, through Dr. B. A. Gould, an invitation to assist in the computations of that work. Professor Ferrel was then teaching school at Nashville, Tenn. Removing to Cambridge, Mass., in 1858, he began the preparation of his paper on the "Motions of Fluids and Solids Relative to the Earth's Surface," and followed this in 1862 with a paper read before the American Academy of Arts and Sciences, entitled, "Note on the Influence of the Tides in Causing an Apparent Error of the Moon's Mean Motion." At this time, it had been shown by Delaunay and Adams that the lunar theory did not give the observed acceleration of about 11″ per century, as had been supposed, but only about 6″, and there was needed something to account for the balance. The object of the paper was to show that, upon a very reasonable and probable lagging of the tides, the effect might be sufficient to cause this, by changing a little the length of the day, the unit of time.

This paper was read only a few weeks before Delaunay read a similar paper before the French Academy. About this time Professor Ferrel placed before the National Academy of Sci-

* Professional Paper No. XIII of the Signal Service.

† Part II, Chief Signal Officer's Report, 1885.

ence, on the invitation of Professor Pierce, a paper containing his discovery of two converging series with simple laws expressing the ratio between the circumference and diameter of a circle. This was subsequently published by the Smithsonian Institute.*

About the same time began the famous "Tidal Researches," originally intended for publication by the Smithsonian, but, on account of the author's connection† with it at the time, published by the Coast Survey. Following these came a series of papers: "Meteorological Researches for the Use of the Coast Pilot," Part I; "On the Mechanics and the General Motions of the Atmosphere," in 1875, Part II; "Cyclones, Tornadoes and Water-Spouts," in 1878, Part III; "Barometric Hypsometry and Reduction to Sea Level," in 1881.

In 1880, Professor Ferrel became interested in the subject of a "Maxima and Minima Tide-Predicting Machine." A paper was read on this subject at the meeting of the American Association for the Advancement of Science, at Boston, and in the following year its construction was begun by the Coast Survey, and it is now in successful operation for tidal prediction at the office in Washington.‡

Professor Ferrel was born in Bedford County, Pa., January 29th, 1817. When twelve years of age, his father moved to a farm in Berkeley County, Va. The boy was kept rather closely at work on the farm, but completed his common school education; and even in that country school-house, with its oiled white paper instead of glass for window-panes, the mind of the future mathematician showed itself in the love for diagrams and odd scraps of scientific intelligence. The first money ever earned, (and it was not enough), went for the purchase of a copy of Park's Arithmetic. The child was too diffident to ask his father for money to buy a book, but with 50 cents earned in harvest time walked to the store in Martinsburg, only to find that the price

* Contributions, No. 233.

† In 1867, soon after taking charge of the Coast Survey, Professor Pierce offered Mr. Ferrel a position in that office, with the special duty of discussion of tidal observations.

‡ Report, Coast and Geodetic Survey, 1883.

of the book was $62\frac{1}{2}$ cents. The storekeeper, however, let him have it for the amount he had. As a young man, astronomy seemed to fire his interest, and without aid other than stray mathematical works afforded, he worked out many problems in connection with the eclipses of the moon. The doors of his father's barn were of soft poplar, and upon these the youth, ostensibly engaged in threshing, drew any number of diagrams, describing circles with the prongs of a pitchfork, and drawing lines with one of the prongs and a small piece of board. Often in later years, in visiting the old homestead, the Professor would look up these diagrams. In 1839, Ferrel entered Marshall College, Mercersburg, Pa. He was always in advance of his class in mathematics. After reaching the Junior class, he spent two winters teaching school in Virginia. He then entered Bethany College, and was one of the first class to graduate from that institution, July 4, 1844. The years following were spent mainly in school-teaching, until asked to aid in the computations for the Nautical Almanac. It is noteworthy that in his whole career Professor Ferrel never once sought position. Every official position has been offered him without solicitation on his part.

As an illustration of his diffidence to put himself forward in any manner, we may instance an incident in connection with his paper on "The Effect of Tidal Action in Causing an Apparent Acceleration of the Moon's Motion." This paper, containing original and important suggestions, he carried to the meeting of the American Academy at Boston time and time again, with the intention of reading, but lacked assurance. It *was* read at last, but deferred so long that it barely anticipated the investigations of Delaunay on the same subject. Professor Ferrel is a member of the National Academy of Sciences, of the American Academy of Arts and Sciences of Boston, of the Washington Philosophical Society, and honorary member of the Austrian Meteorological Society, of the Royal Meteorological Society, London, and of the German Meteorological Society. A. M.

ST. PAUL, MINN., January, 1888.

METEOROLOGICAL OBSERVATIONS DURING THE SOLAR ECLIPSE OF AUGUST 19, 1887, MADE AT CHLAMOSTINO, RUSSIA.

[CONCLUDED FROM PAGE 369.]

DISCUSSION OF THE OBSERVATIONS.

1. *Pressure.*—The barometric readings published in the preceding tables do not give the absolute values of the pressure, as the instrumental corrections have not been applied. They indicate simply relative values, and must be reduced to a common standard before they can be compared with each other. It is not possible to apply the instrumental corrections and to reduce to sea-level before comparison, for the former were not accurately known at the station on account of the disturbances caused by transportation, and the latter involves a knowledge of the elevation of the station, which is not available. It is necessary, therefore, to reduce each to an arbitrary standard, and this is all that is required to determine if any fluctuation was found which can be referred to the effect of the eclipse. The standard adopted was the Casella aneroid, and the readings of the other instruments were reduced to it by applying a correction, which was the mean of the deviations from the corresponding Casella readings for each instrument. In the case of the barograph, it was necessary first to reduce the readings from millimetres to inches, and to determine a separate correction for each sheet of the record. The correction for each of the other instruments was the mean by weights of the deviations noted on the separate days, the deviations showing no changes in the instruments which would necessitate a separate correction for each day. The adopted corrections are as follows:

			Inch.
Barograph, Aug. 18,	1st	sheet	+0.330
	2d	"	+0.334
19,	1st	"	+0.339
	2d	"	+0.337
20,	1st	"	+0.331
	2d	"	+0.338
Watkin			−0.146
Hottinger			−0.092

The close agreement of the corrections for the barograph

shows how accurately the several sheets were adjusted to the revolving drum.

By applying these corrections severally to the separate readings given above in the tables, all the readings of the barograph, Watkin and Hottinger aneroids were reduced to the Casella as a standard. It is not considered necessary to print the reduced readings, as they can readily be derived by any one interested, but the following table gives the mean of the reduced readings of the four instruments, and, therefore, represents the pressure observed at the station as closely as can be obtained from the instruments, giving each equal weight in the determination:

TABLE X.

Barometric Pressure, obtained from the records of the four instruments, reduced to Casella as standard.

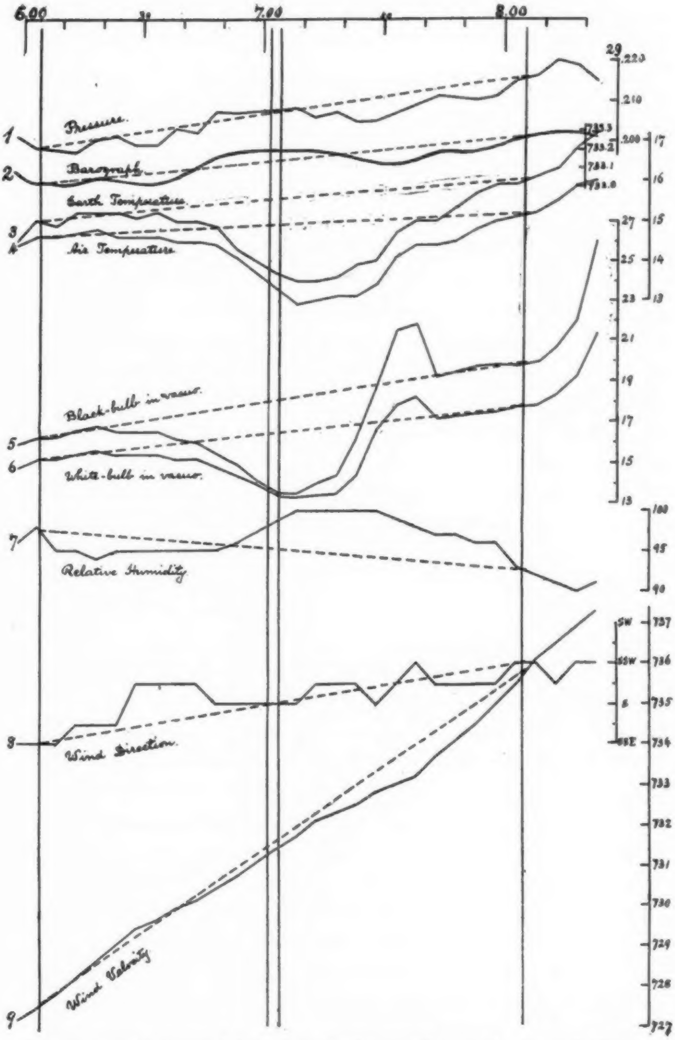
Local Time.	Pressure.	Local Time.	Pressure.	Local Time.	Pressure.
		AUGUST 18.			
6.43 A. M.	29.454	8.43 A. M.	29.440	10.43 A. M.	29.425
7.43 "	.449	9.43 "	.436	11.43 "	.414
		AUGUST 19.			
4.43 A. M.	29.210	6.48 A. M.	29.207	8.13 A. M.	29.220
5.13 "	.198	6.53 "	.207	8.18 "	.219
5.33 "	.194	6.58 "	.....	8.23 "	.215
5.38 "	.194	7.03 "	.....	8.28 "	.214
5.43 "	.199	7.08 "	.208	8.33 "	.215
5.48 "	.....	7.13 "	.206	8.43 "	.218
5.53 "	.200	7.18 "	.207	8.53 "	.222
5.58 "	.201	7.23 "	.205	9.03 "	.216
6.03 "	.198	7.28 "	.205	9.13 "	.215
6.08 "	.....	7.33 "	.207	9.23 "	.214
6.13 "	.197	7.38 "	.209	9.33 "	.211
6.18 "	.200	7.43 "	.211	9.43 "	.211
6.23 "	.201	7.48 "	.....	9.53 "	.211
6.28 "	.199	7.53 "	.210	10.03 "	.208
6.33 "	.199	7.58 "	.211	10.13 "	.210
6.38 "	.203	8.03 "	.215	10.43 "	.210
6.43 "	.202	8.08 "	.216	11.13 "	.225
				11.43 "	.224
		AUGUST 20.			
4.43 A. M.	29.082	7.43 A. M.	29.054	10.43 A. M.	29.064
5.43 "	.068	8.43 "	.050	11.43 "	.068
6.43 "	.064	9.43 "	.050		

Regarding the uncertainty of these values, it may be remarked that the Casella aneroid can be read by estimation to about 0.001 or 0.002, the Watkin to about 0.005, the Hottinger to about 0.002 inch; and the barograph to 0.1 millimetres or 0.004 inch. The

instruments were all very sensitive to minute changes of pressure, and their sensitiveness may be assumed to be proportionate to the accuracy with which their scales can be read. We may, therefore, consider that the uncertainty of the mean values is about 0.002 inch, and the thousandths figure in the above table must be regarded as only approximately accurate.

If we now examine the readings for August 19th, recalling that the eclipse began at 6:04 and ended at 8:05, the total phase occurring 7:02–7:04, we note that the pressure was slowly rising after 5:35 A. M., with a number of small fluctuations. These fluctuations, though small, are probably real, since they are larger than the uncertainty of the values as given above; and this is confirmed by the fact that with the exception of those at 6:43 and 7:13 the readings are progressive, the fluctuations depending upon several consecutive readings, and the above exceptions can be brought into the series by an alteration of only 0.001 or 0.002. The maximum points of the fluctuations occur at about 5:58, 6:23, 7:08, 7:43, 8:13, 8:53, and the minimum at about 5:35, 6:13, 6:30, 7:25, 7:53, 8:28, 10:03.

The chart on page 453 shows graphically the readings between the hours 6:00 and 8:20 A. M., the mean values from Table X being plotted as No. 1, and the tracing of the barograph record as No. 3. The dotted line in each of the curves of the chart is simply a straight line connecting the times of beginning and ending of the eclipse, in order to show the relation of the observed progression to that which would have occurred had the progression been uniform. The fluctuations above noted are clearly shown on the chart; it will also be seen that during the first partial phase the observed pressures were first below, then above, the values for a uniform progression, and that in the second partial phase, they were below these values. It remains to ask if these fluctuations are assignable to the eclipse. This question cannot be positively answered, for (1) the fluctuations are so small as to be very near the limits of accuracy of the observations themselves, and (2) there are fluctuations of equal magnitude at other times, when there was no eclipse. Barograph curves were made continuously for the three days of



The pressure is expressed in inches; the barograph curve is a reproduction of the original in millimetres. The temperatures are in degrees Centigrade. The vertical lines designate the positions in the time scale of the beginning, total phase, and ending of the eclipse.

observation; they show fluctuations on the 18th and 20th, as well as on the 19th, after the eclipse, as marked as those during the hours of the eclipse itself. We may, therefore, conclude that the minute fluctuations noted, while probably showing a real fluctuation in the atmospheric pressure, cannot with certainty be ascribed to the eclipse.

2. *Air Temperature.*—Curve No. 4 represents the observations of air temperature, recorded in degrees Centigrade. It will be seen (1) that the fall was very slow during the first forty-five minutes, then very rapid for twenty minutes; this was followed by a slow rise for twenty minutes, a very rapid rise for ten minutes, and a slower rise thereafter; (2) that the decrease of temperature was about 2.0° C.; (3) that the minimum point was reached about five minutes after totality.

3. *Earth Temperature.*—Curve No. 3 represents the readings of the thermometer, which was placed horizontal upon the ground with its bulb covered with dry earth. The curve is quite similar to that of the air temperature, and the decrease was 2.0°, but the reading at the beginning of the eclipse, the minimum during the eclipse, and the reading at the end, were respectively 0.4°, 0.5° and 0.8° C. higher than the corresponding temperatures of the air. The differences were larger after the eclipse when the sky partly cleared, and the curves during the eclipse would have been markedly different, had not the sky been at that time overcast, or had the eclipse occurred later in the day.

4. *Solar Radiation.*—The two curves numbered 5 and 6 represent the readings of the black and white bulb thermometers, each in vacuo, already given in Table V, columns 5 and 6. The vertical scale of these curves, it will be noted, is one-half that of the preceding. They show (1) a close agreement at the time of totality, (2) that the minimum readings were noted about five minutes after totality. The small difference between the two instruments before totality is due to the cloudiness which then prevailed. A greater difference in the second partial phase is due to the partial clearing at that time, while a still greater difference was noted later in the day, beyond the times given on the chart.

5. *Relative Humidity.*—The curve of humidity, No. 7, illustrates the rise to saturation at about the time of totality, and its continuance for twenty minutes, with a slow fall thereafter. If all the values of the relative humidity determined on the 19th were plotted, it would be seen that the daily decrease which was begun with the earliest observations was not resumed until 10 o'clock, the observations between these times showing an excess of moisture. This general excess can fairly be ascribed to the prevailing conditions of the day, and the special increase during the eclipse to that phenomenon itself.

The fall of dew and its long continuance was one of the most marked peculiarities of the morning. The dew was first noted at the beginning of totality, but it continued to be formed not only long after totality, but even after the end of the whole eclipse, as noted on page 365. It was sufficiently copious to thoroughly dampen the ground and all papers or instruments which were in the open air. The excessive moisture indicated by the humidity observations was evidently favorable to the abundant condensation of dew.

6. *Wind.*—The two curves, Nos. 8 and 9, illustrate the observations of the direction and velocity of the wind. The first of these, taken with the observations at other hours, shows that during the morning the wind was slowly veering from S.E. to S.W. In the first partial phase the wind seems to have changed towards the south a little more rapidly than its average change, and to have recovered its rate in the second partial phase.

The second curve, No. 9, is drawn from the dial readings of the anemometer given in Table V. The chart of all the readings of the morning shows a tendency to a decrease of velocity during these hours, followed by a subsequent increase. The curve during the eclipse hours shows a slight fluctuation, consisting, first, of an increase in the earlier part of the first partial phase, and second, of a decrease in the remainder of the first partial phase and through the whole of the second partial phase. In other words, the wind was a little stronger at first, but as totality approached it decreased perceptibly, and was especially light during the second half of the eclipse, recovering its

strength at its close. That this slight fluctuation is ascribable to the eclipse is uncertain, but it is favored by theoretical considerations, which show that the wind should blow away from the central area of the shadow. At a station situated as Chlamostino, the eclipse wind would be from the W.S.W. before totality and E.N.E. after totality. The effect of such a force upon a wind blowing from S.E. to S.W. would be to increase its velocity before totality and diminish it after totality. It would also cause a deviation in the wind's direction, accelerating the veering S.E. to S.W. in the earlier part of the eclipse, and later retarding it. All these effects are distinguishable in the observations, though in a faint degree.

7. *Cloud Phenomena.*—The notes of the several observers upon the clouds on the day of the eclipse, especially those by Prof. Köppen, give in detail the observations made. The movements of the clouds themselves are interesting in connection with the general atmospheric conditions of the day, but, as far as noted, bear no relation to the special phenomena of the eclipse. Quite otherwise are the notes upon the colors of the sky and clouds. From these it will be seen that at the time of central eclipse, the clouds on the horizon, to a height of 2° or 3° were of a bright orange from the E. point to the S.W.; the clouds in front of the eclipsed sun were red, this color extending downwards and merging in the orange of the horizon. The clouds in the S.W. were dark gray, and a patch of clear sky was distinctly divided by a boundary line which separated the gray tint in the southern part from a faint whitish brightness in the northern part. This same rift is described by another observer three miles distant, where it came in the zenith, as of a dark blue color. The clouds towards the north, above a heavy cloud bank, were also bright, somewhat like a reflection upon silver clouds after sunset. The sky from the N. to the E. was not examined. In order to interpret these results, we must determine the position and dimensions of the shadow at the station. The calculation of the eclipse gives for the diameter of the shadow cone 77 miles, which, projected upon the earth's surface, is 113 miles. The station was about eight miles south of the central

line, as calculated from the data in the English Nautical Almanac. If we assume that the height of the clouds was greater than one-half a mile, then the clouds seen in the horizon would be more than 63 miles distant, and therefore beyond the boundary of the shadow and directly illuminated by the sun's rays. The height above the horizon to which the direct illumination extended, must depend upon the height above the earth's surface of the clouds themselves. The orange glow in the southern horizon extended to an altitude of 2° or 3°, and we may assume, therefore, with a high degree of probability, that this glow was the result of the direct illumination by the sun of clouds beyond the shadow cone. The absence of this glow in the northern horizon may indicate that the clouds there were lower than in the south, but the boundary of the shadow itself was 16 miles farther than towards the south. All the clouds in this direction were probably situated within the shadow cone.

The clouds within the region of the shadow, which were observed as of a gray tint, received their illumination by reflection, and the line of demarcation, so distinctly noted in the S.W., does not indicate the northern boundary of the shadow, as this region was far within the shadow cone. It indicates rather a difference in the reflected light due to the clouds or other objects causing the reflection.

8. *Brightness.*—A marked feature of the eclipse was the brightness during the total phase. There was not the slightest difficulty in reading a watch face, and the estimate of one of the observers that the light was about that at one-half hour after sunset, was confirmed by the estimate of all the observers a few evenings afterwards. The phenomenon of the total phase was therefore quite disappointing, for in addition to the loss of the striking features of the eclipse due to the clouds, it was not even dark. The obscurity was far less than at Caroline Island in 1883, when there were heavy cumulus clouds in various parts of the sky, but a clear space through which the eclipse itself was observed, and was no greater than at Denver in 1878, when the sky was nearly cloudless over the Rocky Mountain region. Judging from this eclipse, the effect of the clouds in reflecting

and diffusing light may even make it brighter than in a cloudless sky.

9. *Miscellaneous.*—Two of the observers record flashes of light resembling distant lightning flashes, which were seen just before the calculated time of totality. (See pages 365 and 367). It was also remarked, though not recorded in the notes, that near the time of totality the increase of darkness seemed to be by distinct stages rather than gradual.

Among the observations planned, but not carried out on account of the cloudiness, was an attempt to photograph the shadow bands which precede and follow the shadow itself. The apparatus at hand was an ordinary traveler's camera fitted with Eastmann's roll holder for paper negatives. The paper was very sensitive, fully as sensitive as the glass negatives in the market. It was thought exceedingly doubtful if the bands could be photographed at all on account of the small amount of light, but in order to make the attempt under the best conditions two large screens were erected, 68 feet from the camera, towards the west. One of these was vertical, the other inclined at an angle of 45°, and both covered with white sheeting. The apparatus was not used, as the bands were not seen but shortly after the total phase two instantaneous exposures were made, one 4 min. 8 sec., the other 8 min. 56 sec., after the calculated end of totality. At these times, the amount of sunlight was only 0.08 and 0.18, and the light proceeded from the limb of the sun where the actinic power is small. The time of exposure did not exceed one-tenth of a second, but even under these conditions the white screens were sharply defined in both pictures, and the more distant objects of the landscape were well seen in the first, and their details satisfactorily given in the second. While we may suppose that this favorable result was largely due to the increased actinic power resulting from cloud reflections, which would be wanting in a cloudless sky, still it does not seem impossible from these experiments, that the shadow bands may be successfully photographed at some future eclipse, especially if more sensitive apparatus be employed.

An indirect result of the observations of this eclipse is to ex-

plain the peculiar barometric curve obtained at Caroline Island in 1883, and thought to indicate the true fluctuation due to an eclipse when observed under especially favorable circumstances. This fluctuation was noted with the Hottinger aneroid, which was then employed alone, while in the last eclipse it was used with three other instruments. It was found in discussing the latter observations, that the correction table for temperature furnished by the maker and carefully attached to the instrument, was given with the wrong algebraic sign. On the detection of this error the temperature coefficient was carefully redetermined, and its numerical amount also found to vary somewhat from that given, but this change was not greater than such an instrument is subject to after use for several years. The observations at Caroline Island, when reduced with the revised temperature coefficients, show only a minute fluctuation which is of about the same magnitude as the uncertainty of the readings themselves.

Summary.—We may condense in a brief paragraph the results of the above discussion. The temperature and humidity fluctuated, as is usual in eclipses, the former showing a fall, and the minimum occurring a few minutes after the total phase, and the latter showing a rise, which in this eclipse was to the saturation point. The minimum temperatures recorded by a thermometer in the shade, and by black or white bulbs in vacuo freely exposed, differed but a few tenths of a degree from each other, and were also a few tenths lower than the air temperature at 4:13 A. M., twenty-three minutes before sunrise. Minute fluctuations of barometric pressure, and of the wind's direction and velocity, were observed, which cannot with certainty be attributed to the eclipse, but which in the case of the wind can be so ascribed with some probability. The cloud tints show the appearance of clouds, some of which were within, and others without, the region of the eclipse. The most marked features observed were the long-continued deposit of dew and the great brightness of the landscape during the total phase.

WINSLOW UPTON.
A. LAWRENCE ROTCH.

THE CLIMATE OF SOUTHERN RUSSIA AND IOWA COMPARED.*

To the general public this comparison may seem to be without practical value, but at the present time, every horticulturist in Iowa and the Northwest will immediately recognize the material importance of this subject. For, just now, many horticulturists in Iowa and in states and territories adjacent are privately, and with state aid, engaged in the introduction of Russian apples to take the place of those fruit trees which, having grown and borne more or less abundantly in our climate for from a quarter to a half a century, have largely been destroyed by our severe winters. During the last half dozen years we have had a succession of winters entirely without precedent in the records now extending over half a century.

PRETENDED RATIONAL HORTICULTURE.

The introduction of the "Russians" into Iowa is supposed to be a step in rational horticulture, on the ground that these Russians come from a climate which is claimed to be practically the same as that to which they are introduced. This claim is very generally made by those who are taking a leading part in this transplantation from Russia to Iowa. It may hardly be necessary to present instances before the members of this society; for this topic has been quite prominent in our meetings for some years past. Still one or two special quotations may be advisable for those who have not been present at these meetings. Mr. R. P. Speer, for many years a director of this society, twice its president, and now, next to Professor Budd, the most active worker in favor of Russian Apples, says: "Near Moscow the conditions (of climate) are similar to ours, and from there we have obtained many varieties invaluable in northern Iowa. Professor Budd and Mr. Charles Gibb made a large importation from there" (Report for 1886, p. 355). On the next page he adds: "Trees from inland Russia *are* adapted to our climate; with them we *will* succeed." The same high, practical

*A Climatological Study on the Transplantation of Russian Fruit to Iowa and the Upper Mississippi Valley. By DR. GUSTAVUS HINRICH, Director Iowa Weather Service. Read before the State Horticultural Society of Iowa, January 17, 1888.

authority says (Report 1885, p. 543): "The winter varieties which I have full confidence in, were imported from central Russia three years ago, by Professor Budd, but they have not fruited in Iowa yet. If they were good, hardy winter apples in *central Russia, where the climate and soil are similar to ours,* why should they not be the same here?"

It is impossible to be more explicit in stating that the introduction of these Russians is undertaken because of the supposed similarity of climate, and not because they *have* proved themselves "by their fruits," grown and ripened in Iowa *for years,* to be really successful in Iowa.

The same idea pervades nearly all that Professor Budd has written or said on this great topic. Already in his first most important publication on this subject, he concludes a very brief note on the climate of the "wonderful plain" by the following very positive and very broad statement: "From these notes the idea may easily be gathered that we can find provinces in central Russia where the summer and winter conditions approach ours very closely." (Bulletin of the Agricultural College, 1883, p. 7.)

The strictly pomological discussions on this great practical question were particularly interesting at the last meeting of this society at Charles City. (Report, 1886, pp. 125-130.) It has been taken up by members of this society in public journals since that meeting. Members of equal experience in practical horticulture are found on opposite sides of this question.

I need not say that I am not qualified to take any part in this phase of the great question, beyond stating that my sympathies are on the side of the Russians. Some years ago, I had ten acres of bearing Iowa orchard, and had apples in abundance; but the severe winters have destroyed these orchards, so that they have been converted into corn-fields, and I have myself planted "Russians" in a small way, some four years ago. I say this simply to prove that I have no possible reason to oppose the "Russians."

But while my able horticultural friends are discussing this question, and draw opposite conclusions from the facts in their

possession, I have been led to more carefully look into the climatic conditions of that part of Russia from which the fruit has been introduced, for the reason that it *must* do well here because the "climate of Iowa is *said* to be nearly the same as in the Russian home" of this fruit. Now, while I cannot take part in the horticultural question proper, the climatological conditions of Iowa and Central Southern Russia are well enough known to me from observation and long continued, perfectly authentic records, that I may be permitted to form and express an opinion on the supposed climatic resemblance upon which this enterprise in rational horticulture is based.

GREAT ECONOMIC IMPORTANCE.

Before I proceed to present the facts in the case, it may be well to state that this phase of the question is of not a little practical importance. For if the supposed close similarity of climate be not a fact, then the final decision on the value of Russian fruit to Iowa cannot possibly be obtained in less than a quarter of a century from now. We all know how long certain apple trees have appeared to be just the thing for Iowa; and yet, in the end, they have proved total failures! If the identity of climate on which the friends of the Russians base their enterprise, be not a fact, they will have to defer their final opinion until the Russians have been pretty extensively grown in Iowa long enough to have experienced all sorts of Iowa seasons—the *hot* as well as the cold, and the *wet* as well as the dry!

If the supposed close similarity of climate be not true in fact, *the test of the Russians in Iowa can only be completed empirically*, and it would be unpardonable to devote all means and time to their cultivation. In this case, Iowa might in a dozen years from now be as badly off for fruit as it is to-day.

If the rational basis on which the Russians are introduced into Iowa be not well founded, it will be the duty of the horticulturists of Iowa to give only a portion of their time and means to the Russians, and devote not a little work to the development of new varieties on our own soil, and to retain and propagate the best that may so arise.

If the climate of Iowa, as a matter of fact, cannot be found

anywhere in Russia, it follows that Iowa horticulturists must continue to persevere in developing such new fruits as will prove themselves worthy of cultivation, and exactly adapted to Iowa climate. In that case, the imported Russian sorts will mainly be valuable in furnishing additional strains of good blood for crossings and seedlings.

NO IOWA CLIMATE IN RUSSIA.

In closing this introduction, it may be as well to state the final results of the climatological study now following, namely, that there is not anywhere in the great plains of central and southern Russia in Europe a province or district possessing a climate that is closely similar to the climate of Iowa in its essential and dominant features. And it may be further stated as a matter of fact, that the regions in Russia from which importations of apple trees have been made into Iowa are from four to eight hundred miles distant from the locality that corresponds most nearly in temperature to Iowa; and neither this locality, nor any part visited by our importers, resembles Iowa in regard to rainfall.

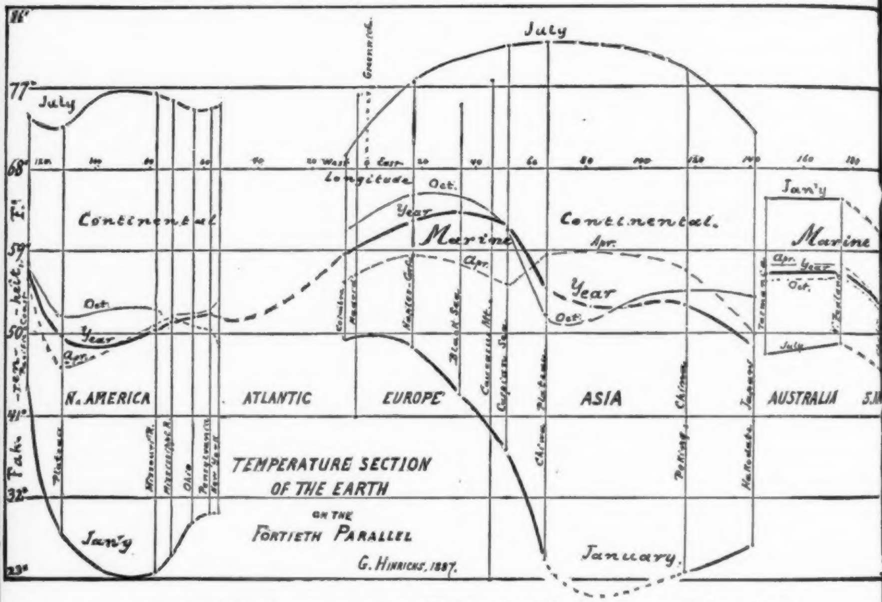
It is indeed strange that practical men speak of Iowa as arid, (Prof. Budd, Bulletin Iowa Agricultural College, 1883, p. 7), and compare it to parts of Russia, where the normal rainfall is less than what Iowa receives in a year of extreme drouth.

The importations into Iowa made so far will probably benefit Dakota and Minnesota much more than Iowa, because the climate of Bismarck resembles that of Kazan, and the climate of Ssaratow resembles that of St. Paul, so far as these climates can be compared at all. And the western parts of Russia from which importations have been made, may benefit Michigan more than Iowa; for from Kiew to Riga the climate resembles that of Michigan rather than that of Iowa in its thermic conditions.

CLIMATE ON THE FORTIETH PARALLEL.

To be able to intelligently compare the climate of Iowa with that of distant regions of the globe, we will do well in taking, mentally, a trip around the globe on a parallel of latitude. This will conclusively demonstrate that latitude is not as prominent

a factor in determining climate as most persons believe. For the sake of greater convenience we shall take the parallel of forty degrees latitude, both north and south—that being the full ten degree nearest to Iowa drawn on all globes and maps of the world. In this preliminary comparison it will be sufficient to consider the temperature only.



I shall furthermore give all data in tabular form at the close of this paper, and use here only such graphical representations thereof as I have found to be most readily understood. Thus to show how the climate, as to temperature, varies on the fortieth parallel, I have constructed what properly is a *temperature section* of this parallel, on which the length of the vertical lines marks the corresponding height of the mercury in the thermometer for the period specified, while this line itself is drawn at a point determined by the longitude of the place of observation. Joining the corresponding points for the different places, we obtain a *curve* that correctly and conspicuously repre-

sents the comparative condition of temperature on this parallel of latitude for the time specified.

For this general comparison it is fully sufficient to take the mean temperature for each of the two extreme months of January and July, together with the mean temperature of the middle spring and fall months of April and October. To these is added the mean temperature of the entire year.

The temperature section of the fortieth parallel constructed by me in this manner is herewith presented. The horizontal lines mark the degrees on the thermometer scale specified, corresponding to every ninth degree Fahrenheit and every fifth degree Centigrade, from the freezing point upwards and downwards. The scale adopted is 10 degrees Centigrade to the inch. The scale of longitude adopted is 60 degrees to the inch.

On this diagram we first note the two great continents of America and Asia-Europe separated by the Atlantic. We see that the mean temperature varies along this latitude from about 48 degrees F. to 64, or fully 16 degrees. We also notice that it is highest throughout the European part of this section (Mediterranean Region) and on the Pacific Coast in America (California); also, that it is lowest throughout the interior and clear through to the east coast of the continent of America and Asia.

Now, such a difference of sixteen degrees in the mean annual temperature of a place corresponds in our valley of the Mississippi to a change in location from Iowa City to middle Louisiana. So large are the differences in the mean temperature on the parallel of forty degrees latitude North around our globe!

But the differences in thermic climate are much greater yet when we take into account the course of the temperature throughout the year. For we notice that as the mean temperature of the year is lower in continental regions, the July heat is somewhat higher, and the January temperature very much lower. From this it follows, as also plainly seen on the diagram, that the *range* from the mid-winter to the mid-summer month is greatest in the continents. These marked characteristics have led meteorologists to distinguish between continental and marine or oceanic climates.

Under the same latitude the marine climate is warmer, has a colder summer, and a much warmer winter than the continental climate; its annual range in temperature is very small. It is equable in character, and mild.

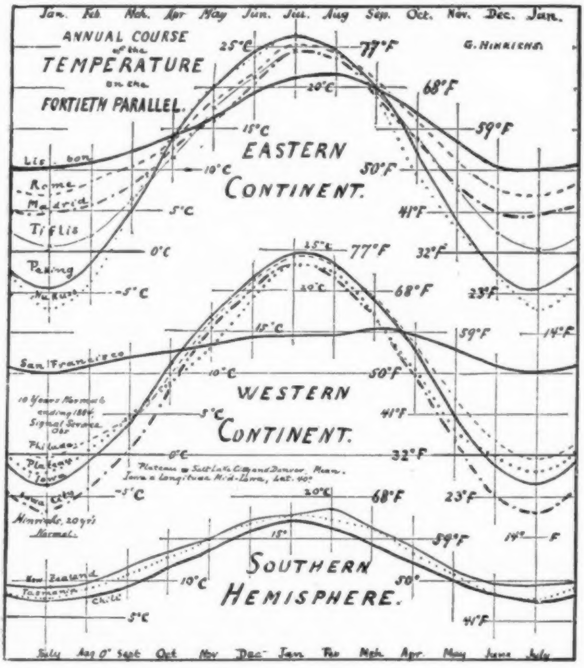
The continental climate is colder in its annual mean temperature; but it has a higher summer heat, and especially a much greater winter cold, so that its yearly range in temperature is excessive. It is a climate of extremes, and severe. The change from winter to summer is great, and usually takes place in a short time. Also the irregular changes from day to day are much greater in the continental than in the marine climates.

By looking at the diagram we see further, that under the fortieth parallel of latitude south the climate of America and Australia is oceanic; that true continental climates we find only on the northern parallel of this latitude.

It will also be seen that Europe is especially favored, particularly under the parallel here considered. For about fifty degrees of longitude, from the coast of Portugal to the shores of the Black Sea, the climate is essentially marine, though getting gradually more severe as we go eastward. This is due to the great extent of the Mediterranean Sea. The equable climate of Naples, where July is about equal in temperature to that of Iowa City, has a January like our April, while our January averages nearly thirty degrees colder; and yet Naples and Iowa City are nearly under the same parallel of latitude! The annual range in temperature at Naples is about thirty degrees. Here at Iowa City it is nearly sixty degrees between July and January! The American continent has barely a western coast line of moderately marine climate, while on the western continent nearly all of Europe may be said to have a marine climate, which on every parallel of latitude very gradually passes into the continental climate of central Asia, the most pronounced and most severe continental climate on this globe.

Eastern Europe, that is Russia, forms the transition region from marine to continental climate of central Asia; on the west we have in Germany a more rigorous marine climate, which is decidedly moderate when compared to that of eastern Russia.

The temperature section given takes account only of the extreme and mean months of the year, and therefore must be supplemented by a diagram showing the course of the temperature throughout the entire year at prominent points on the fortieth parallel considered. Accordingly, I present such a diagram, constructed on a temperature scale of 20 degrees Centigrade to the inch, and a time scale of four months to the inch. I present



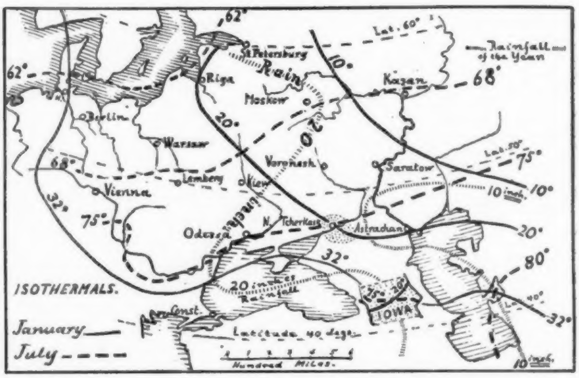
the curves in three groups, namely, one for the Eastern Continent, another for the Western Continent, and a third for the Southern Hemisphere. All these curves are very carefully constructed on double the scale of the cut, from the best data given in tabular form at the close, and are therefore perfectly reliable. The curve marked "*Plateau*" is the mean of the values for Salt Lake City and Denver. The curve marked "*Iowa*" is the mean

of Omaha and Leavenworth on the Missouri, and Davenport and St. Louis on the Mississippi, thus representing a point under 40° 3′ Lat. N. and Long. 94° west of Greenwich; that is, a point on the fortieth parallel of latitude almost exactly on the middle meridian of Iowa. The curve marked "Iowa City" represents my twenty years' normal from 1861 to 1880.

These annual curves show most strikingly the equable marine climate of Lisbon, San Francisco and the Southern Hemisphere, in contrast with the excessive, continental climate of Peking and Iowa City.

THE CLIMATE OF RUSSIA.

In order to get a more definite idea of these relations, I have drawn the isothermal lines for January and July according to the great Atlas of H. Wild, between the sixtieth and fortieth degree of latitude, and from Hamburg in Germany to Nukuss near the sea of Aral.



Upon examination of this map it will be seen that under the latitude of 55 degrees the yearly range in temperature increases from about 30 degrees at Hamburg to 60 degrees at Kazan. The first is truly marine, comparable to the yearly range at Naples; the last is strictly continental, comparable to that at Iowa City. The distance from Hamburg, Germany, to Kazan, East Russia, is 1,500 miles.

That the change from the marine to the continental climate is not abrupt, may be seen from the following table :

MEAN TEMPERATURE.

Latitude 45°.	January.	July.	Range.
Hamburg	32	62	30
Riga	20	63	43
Moscow	13	68	55
Kazan	8	68	60
Latitude 55°.			
Vienna	30	71	41
Odessa	26	74	48
Astrachan	20	77	57
Nukuss	20	80	60

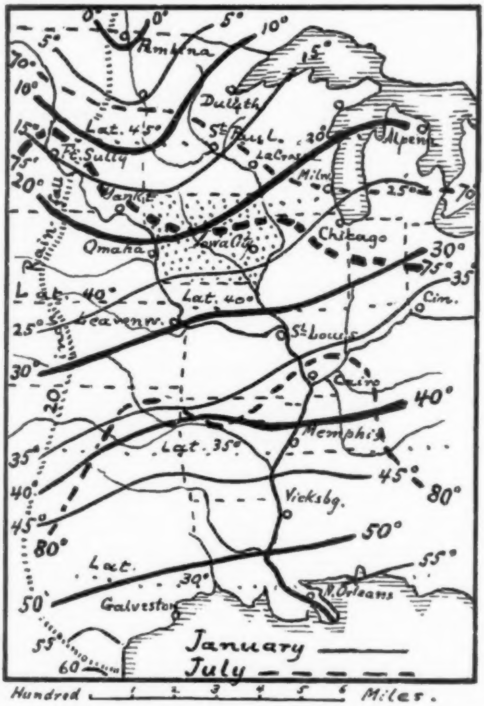
I have given the temperatures only in the nearest entire degree Fahrenheit, and selected noted places near the latitude specified and about five hundred miles apart.

It will be noticed that the January temperature falls from 32 to 8 degrees in going from Hamburg to Kazan, while the July temperature rises only from 62 to 68 degrees ; that is, the midwinter month is 24 degrees colder at Kazan, but the mid-summer month only six degrees warmer. In other words, the temperature of January is lowered four times as many degrees as the summer temperature is raised, while the range is exactly doubled. This greater change in winter than in summer temperatures will be recognized as the leading character in continental climates.

The changes under latitude 55 are less marked, because so much farther south; at the same time, it must be remembered that Vienna is already somewhat continental in its climate.

Before we leave this interesting map, I wish to call especial attention to the remarkable fact that both the lines of equal July and January temperatures cut the parallels of latitude under a considerable angle, instead of running nearly parallel thereto. The January Isothermals run from northwest to southeast, and winter cold increases most rapidly in the direction from southwest to northeast. The July Isothermals intersect the preceding almost under a right angle, at least in western Russia; accordingly, the summer heat increases most rapidly

in a direction from northwest to southeast. Instead of north being coldest and south warmest, we thus see that in all of southern Russia, northwest is the direction of greatest cold in summer and northeast the direction of greatest cold in winter.



But northwest points to the ocean and moisture, northeast toward the continent and dryness, thus causing specific climatic relations, peculiar to Russia, and not found in our Mississippi Valley.

On this map I have also entered the lines of equal rainfall according to *Woeikoff* (see Klimate der Erde, 1887, Vol. 2). It will be seen that just above the Caspian Sea, between Ssaratow and Astrachan, the rainfall for the entire year is only ten inches and less; that through all of Russia to be considered by

us it is between ten and twenty inches only, reaching this latter amount on a line running from Petersburg over Moscow and Kiew to Odessa. The distribution of these rains throughout the year is similar to that in the upper Mississippi Valley, being greatest in the summer months.

CLIMATE OF THE UPPER MISSISSIPPI VALLEY.

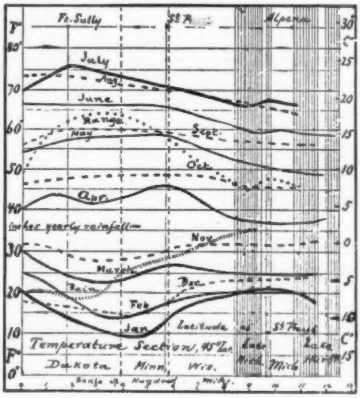
Having made ourselves somewhat acquainted with the distribution of temperature and rainfall in Russia, we are ready to examine a corresponding Map of the Mississippi Valley, (see map on preceding page), drawn on exactly the same plan but twice the scale. It is strikingly apparent that the isothermals cross the Mississippi Valley mainly in a direction from west to east; that however, the great lakes cause the January Isothermals to bend north and the July Isothermals to bend south. This deflection is due to the immense body of water in these lakes, reducing the extremes, cooling the summers and moderating the winters, thus giving this part of our continent a somewhat marine climate. The peninsula of Michigan, surrounded on three sides by this inland sea, ought to show this influence the most; and so it does in fact. It is owing to this tempering effect of the lakes surrounding it that Michigan has become the most successful fruit producing State of the Northwest.

To show this tempering influence of the lakes I have constructed (see following page) a temperature section for the latitude of St. Paul (45° North) extending 1250 miles west from the east shores of Lake Huron.

The scale of this cut is 650 miles and 40 degrees F. to the inch. The names below indicate the states and territories passed through by this parallel; the lakes are distinguished by vertical shading. The meridians at Fort Sully, Dakota, St. Paul, Minn., and Alpena, Mich., are drawn; so are the boundaries intersected by the parallel named. In order more readily to distinguish the monthly temperature section, they are drawn as full lines for the rising season from January to July, and in dotted lines for the falling season from August to December.

It will be seen at a glance that both winter and summer months increase in severity as we on this parallel of St. Paul

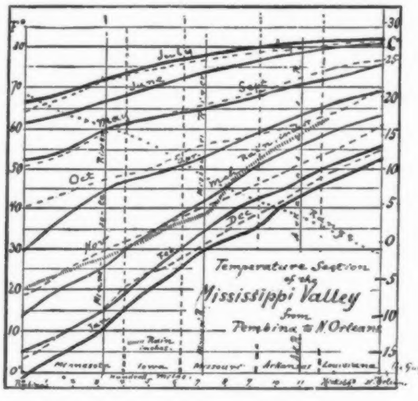
travel from the lakes westward. From about 45 degrees F. in Michigan the range increases to about 60 degrees in eastern Dakota on the same parallel.



The domineering climatic powers in the Mississippi Valley proper are the immense body of hot water of the Gulf of Mexico in the South, having a temperature of about 75 degrees all the year round, and the vast expanse of continental British America in the North ; and to limit the atmospheric battle-field between these two opposite powers to the Mississippi Valley, one of the grandest mountain chains stands in the west, and rests on a high plain gently sloping down eastward to the Mississippi River.

A glance at our longitudinal temperature section of the Mississippi Valley, will show the import of these facts more clearly. In the South, on the shores of the gulf, we have an annual range of only thirty degrees, as we found it at Naples. In the North, at Pembina, near the British line, the mean temperature of January is seventy degrees below that of its July temperature. Hence the temperature section from the gulf northward declines but little in summer, but is very steep in winter. In July, New Orleans is but fifteen degrees warmer than Pembina, but in January Pembina is 56 degrees colder than New Orleans.

There is probably not another equally large portion of the globe that has in summer as equable a temperature as our Mississippi Valley, and this temperature is high, and insolation intense, because of the low, almost subtropical latitude. Right close to the south, the immense boiler of the Gulf is furnishing vapor; the heated continental expanse north causes the southerly current prevailing throughout the summer. These southerly winds carry the moisture of the gulf all over the Mississippi Valley, where it descends in fertilizing rains, normally in great abundance, making it the best watered valley in the world. The farther north from the gulf, the smaller the amount of



rainfall—but even a thousand miles north of the gulf, in northeastern Iowa, we have normally yet an annual rainfall of one yard in depth! To speak of Iowa, right in the center of the Upper Mississippi Valley, as of an arid region, is to contradict nature; to compare Iowa, which normally is covered with about a yard of rain-water in the course of each year, with southern central Russia receiving only about one-third as much, is preposterous. Iowa is not one of those arid portions of the globe that receives only about an inch a month of rainfall, though some of our new teachers would have us believe that were sufficient. No, when the greater part of Iowa received only one and a half to two inches of rain a month, all her people complained

of extreme drouth. The line of twenty inches of rainfall runs over two hundred miles west of Iowa.

In winter the great thermic gradient of the Mississippi Valley, is the real cause of the sudden changes in our weather. In this thermic contrast between north and south we have the true origin of our blizzards and cold waves. This great difference in temperature makes it possible for us to have a thunder-storm in winter, followed in a few hours by a blizzard. The irregular changes of temperature from day to day are accordingly much greater in the Mississippi Valley than in Russia. Our so-called cyclonic storms travel about twice as fast as those in Europe and Russia.

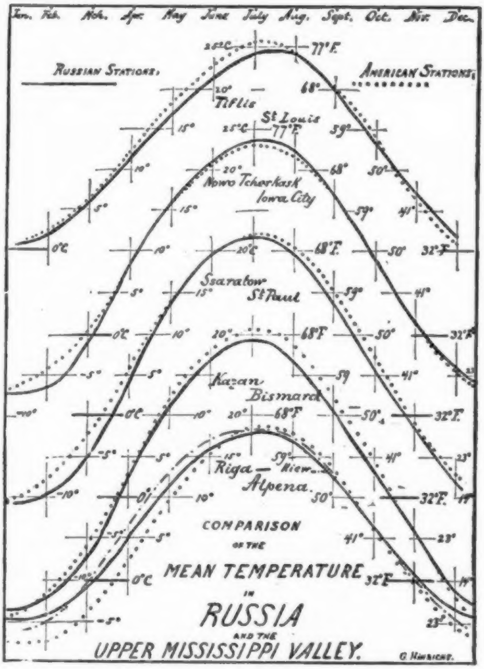
SEARCHING IOWA CLIMATE IN RUSSIA.

The isothermals of the map being determined by Signal Service observations, are somewhat high; we may therefore take the intersection of the 20° January and 75° July isothermals as being in fact central in Iowa. Now, where in Russia will we and a district or province that has an Iowa July and January temperature, and thus would correspond to the climate of Iowa in this first and most important general condition?

To find this thermic Iowa in Russia we follow the July isothermal of 75° from Odessa on the Black Sea beyond Ssaratow on the Volga River, and also trace the January isothermal of 2 0 from Riga on the Baltic, past Minsk, Kiew, Charkow and Nowo Tsherkask to Astrachan on the Caspian Sea. Where these two isothermals intersect, we have that district of Russia in which January and July correspond in temperature to Iowa. This is near Nowo Tsherkask, just above the Sea of Azow. By examining the curves showing the yearly course of the temperature at Iowa City and Nowo Tsherkask we see that the mean curve of the temperature in these two places corresponds as closely as can well be expected for two so distant and so differently situated localities. Yet the climate of these two places is not similar in the other essential respects, as already explained in general; especially the rainfall is very much less at Nowo Tsherkask than at Iowa City. (See cut below.)

In order to give the clearest possible idea of magnitude, lati-

tude and thermic relations of Iowa and Russia compared, I have drawn a map of Iowa true to scale and in its proper position in latitude on the map of Russia, arbitrarily locating it in the Caucasus as to longitude. The January and July isothermals are also drawn, and the map is dotted like its thermic counterpart around Nowo Tsherkask.



If it had been intended to obtain fruit trees for Iowa from a region of Russia most closely corresponding to that of Iowa, they should have been sought here. But the region specified is inhabited by Don-Cossacks and Calmucks, not much given to raising fruit ; they are admirable herdsmen and horsemen. No apple trees from this part of Russia have been brought to Iowa, nor have Prof. Budd and Mr. Gibb come near this region. When at Voronesh, the nearest to Nowo Tsherkask, they were

yet about 480 miles north of the region which in temperature corresponds most nearly to central Iowa. In his narrative (p. 15), Mr. Budd remarks that "Dr. Fischer, director of the pomological institute at Voronesh, had not heard of some of the most popular apples of Kazan and Ssimbirsk, on the Volga." As Kazan is nearly 500 miles northeast of Voronesh, and has a January temperature six degrees lower, and a July temperature two degrees lower, than Voronesh, Kazan apples would probably not be important at Voronesh. A nursery man at Des Moines, Iowa, may not deem it necessary to know all apples doing well at St. Paul, Minnesota.

As these travelers have not come near any part of Russia in which the temperature corresponds to that of Iowa, we may try to determine how their Russian trip might thermically be laid down on the map of the upper Mississippi Valley. By applying the method above used and exemplified, it will readily be seen that Riga and Kiew in Russia correspond to Michigan; Voronesh and Orel to northern Wisconsin; Ssaratow to St. Paul, Minn., and Kazan to Bismarck, Dakota. The diagram showing the mean annual course of the temperature at these places shows, better than words could do, that thermically these places are very near equivalent. I may add that southward we have in both continents Nowo Tsherkask, corresponding to Iowa City, Iowa; and Tiflis, to St. Louis, Mo.

But it should not be overlooked that this thermic equivalence does not, by any means, imply a general climatic identity, or even similarity; not only that even thermic variations differ notably, but, above all, in regard to rainfall, the two regions are really not comparable. What to us is a drouth, in Russia is a normal quantity. Eminent Russian authorities are well aware of this notable contrast. Says *Dr. A. Woeikoff*, in his work "On the Climates of the Earth," Vol. 2, p. 230 (German edition, 1887): "Drouths in southern Russia are not uncommon. * * * * The reason is simply this, that there does not fall rain enough for so hot a climate," and he proves it by comparing the temperature and rainfall of Lugan, Odessa, and Kischinew, Russia, with the corresponding values of Iowa City,

Iowa, and Ottawa, Illinois. The result of his comparison is that in these places of equal May and July temperature, the rainfall in the Mississippi Valley is two and one-half to three times as great as in the corresponding stations of South Russia.

CONCLUSIONS AND APPLICATIONS.

No wonder, therefore, that Russian plants have developed those thick leaves so often described, while plants indigenous to Iowa and the upper Mississippi Valley have not found it useful or necessary to do so. How these Russian plants will be modified by our much more moist climate, time alone can tell.

Plants possess a very considerable power of adaptability to climatic conditions not identical with those under which they originated and developed. Russia has a continental climate ; so has Iowa and the Upper Mississippi Valley. Rains are mainly summer rains in both regions—scant in Russia, generally abundant in America. Changes in temperature from day to day are great in Russia, but much more severe in our part of America. Russia has the Buran—we have the Blizzard, which is not less. We may therefore expect to obtain many hardy plants from southern and middle Russia that will readily acclimatize themselves here and prove quite useful and valuable to us in corresponding regions.

But when we are told that fruit trees *will* succeed with us *because* they have been brought from such portions of Russia as correspond in climate to Iowa ; and when upon closer examination we find that this Russian climate in some very essential particulars is not similar to ours at all, and that furthermore these plants came from Russian provinces that in thermal conditions resemble Michigan, Wisconsin, Minnesota and Dakota, but not Iowa ; we are compelled to say that it is not at all certain and really not even probable, that these fruit trees will do well in Iowa, and *we therefore must deny that the introduction of these fruits into Iowa rests upon a rational foundation assuring success.* On the contrary, it seems necessary, that these fruits, so far as their quality be desirable, should be tested exactly as all others have been tested, namely empirically, by

actual and sufficiently extensive and continued trial at as many stations as may seem advisable.

The comparisons of climate here made will, it is hoped, assist in selecting places from which to import Russian fruit for any given part of the Upper Mississippi Valley, so that the thermic change the imported plant will have to submit to may average as low as possible.

The importations thus far made of Russian fruit have all come from places in Russia having both a lower winter and summer temperature. *It is therefore not at all to be expected that winter apples imported from these places will also be winter apples in Iowa*, if they succeed well in Iowa at all; not only on account of the higher summer temperature, but also on account of the greater insolation, due to much lower latitudes, all these fruits must be expected to be much earlier in their new home than they were in Russia.

But even if in these Russian fruits only new strains of hardy trees have been furnished our experimenters and breeders, much good will have been done to Iowa.

I conclusion I may repeat that personally I do hope that we shall be able to acclimatize some the best Russian apples and other fruit. The present study of the climate of the two widely distant regions in question was demanded by the peculiar conditions of the problem. I trust that the results obtained will prove useful to the horticulturists of Iowa, and may aid in the work of growing good fruit in Iowa and the Northwest.

(The temperature tables will be printed in the Horticultural Report).

CORRESPONDENCE.

LOCAL WEATHER PREDICTIONS.

To the Editors: The recent discussion of this question in this journal has developed many interesting and, to me, unexpected points. While I think it hardly necessary to review these points, as they explain themselves, yet it may be well to remark upon them from another standpoint for the benefit of

some who may not have read the whole discussion. In the January number, Mr. Davis, referring to my original paper in the December number, says a "totally ignorant person" would not know whether to predict rain or fair; I think it plain that a person may be "totally ignorant" of meteorological laws, and yet know enough "to come in out of the wet." Mr. Davis thinks that an editor would be unwilling to publish a prediction of "fair" every day in the year, but might be willing to give out the honest endeavors of anyone trying to benefit the public, even though the percentages were less. I think an editor would be inclined to state once for all that a prediction of "fair" would be the more satisfactory, and rely upon his readers to remember that fact. I do not think any editor would knowingly publish a prediction that would give a less percentage than one of "fair." Mr. Davis has emphasized the very points that I have urged, by his expression "meaningless comparisons."

The statements of Mr. Clayton seem much more to the point, and yet, when properly understood, do not meet the facts in the case. For reasons which I will not specify here, I cannot go into several of Mr. Clayton's statements regarding his methods of verification and comparison. I will say, however, that I believe Mr. Clayton will sometime be exceedingly astonished at his extreme misapprehension of the work of others.

Mr. Clayton seems to imply that I had selected purposely the hottest and dryest months of 1887 for my comparisons. If he had looked a little farther he would have seen that I had selected *all* the months available. I had stated also that predictions of a fair or foul day made at sunset were susceptible of a high percentage, and this shows that they cannot be compared with predictions made at 2 P. M. I have now taken out all of Mr. Clayton's percentages, and have placed them in groups, as follows:

	Dec., 1886.	Jan., 1887.	Feb.	March.	April.	May.	June.	July.	Mean.
Sunset.........	77	81	79	74	83	77	87	74	78
	Aug., 1887.	Sept.	Oct.	Nov.					
2 P. M..........	71	70	76	66					71

It will be seen that the highest percentage of all is in one of

the months declared to have a deficiency in rain-fall. It would seem as though Mr. C. is wrong in his view that settled weather will give a skillful man a relatively less percentage than "fair," while in unsettled weather the reverse would be the case; as a matter of fact, the higher value should be obtained in settled weather for both the able and ignorant man; and one reason why the less percentage is shown for Mr. C. in the last four months is because the prediction is made at 2 P. M. instead of at sunset. This is a partial explanation of the greater difference which he finds in his figures.

So much has been said about local predictions and their value that it may be well to ask whether, after all, the opinions advanced as to their value are not due to an almost total misapprehension of the methods employed by others. We have an interesting proof of this in *Science* for January 27, p. 50. It seems that Messrs. Clayton and Hazen have been making predictions for Boston, which are directly comparable. Mr. Clayton was near the spot, and made his predictions at 2 P. M., with the aid of the S. S. morning map, for the succeeding twenty-four hours (midnight to midnight). Mr. Hazen was more than 300 miles away, as the crow flies, and made his predictions for the same interval, but from the 7 A. M. map, and several hours earlier. Mr. Clayton obtained in October 80 per cent., and Mr. Hazen, 96 per cent., when verified by Mr. Clayton's rules.

It would seem that both Mr. Davis and Mr. Clayton have missed the most important deduction to be made from all this discussion, which, to my mind, is this: Suppose some one should undertake to state at noon, each day, whether the mean temperature for the twenty-four hours from the preceding midnight to the next would vary with in 5° of the previous twenty-four hours; without doubt, such a prediction would be verified nearly 100 per cent. Suppose, now, the prediction were for the interval from the 6 A. M. before to the succeeding 6 A. M.; the verification would be less than before. We might go on in this way and it would not be long before we would reach a twenty-four hour interval, when the prediction would be a guess, en-

tirely valueless as showing any knowledge of the temperature. It seems to me that the attempt to predict the temperature and weather for an interval of thirty-four hours is shown conclusively to be entirely beyond our skill at present. I do not mean that we shall never attain such skill as to do better than to predict stationary or fair; I believe we shall. If any one doubts this position, let him try to predict the temperature for thirty-four hours, and see how often he will acknowledge that his prediction is a pure guess. An additional proof of this is the fact that Mr. Clayton has often predicted that the mean temperature would rise five to ten degrees, and it has actually gone down. The above proposition, while perfectly plain in the case of a temperature prediction, is not quite so in the case of weather; yet it seems to me that it is true also in the latter case.

The main purpose I had in view, namely, to object to "meaningless comparisons" in weather predictions, has been completely realized.

Note.—Since writing the above Mr. Clayton has published his December percentage, and this gives thirteen months of sunset and 2 P. M. predictions. It will be of interest to compare mean values in conjunction with the rainfall.

	%		%
Rainfall below mean	77,	above mean	79
Rainfall —.50 inch and below	78,	—.50 or above	78
Rainfall —1.00 inch and below	79,	—1.00 or above	77.

This table seems to show little difference, and is complicated from the fact that sunset and 2 P. M. are mixed together. The three months having the greatest deficiency in rain showed the lowest percentages, but the three months having the highest percentages also showed a great deficiency in rain. I have no doubt that the general proposition is true, "other things being equal, settled weather will give the higher percentage." The relative advantage of the unskilled predictions in the summer months seems to be admitted, and this is all that need concern us; that the general average for the year is pretty good does not count in this connection. GAN.

January 28, 1888.

To the Editors:

The only reply which seems necessary to the above article of "Gan's" is to correct a few misapprehensions and mis-statements. In stating that the earlier predictions of Blue Hill were sunset predictions, it hardly seems possible that "Gan" could have read the previous articles on this subject to which his own was apparently intended as an offset. Mr. Rotch distinctly stated in his article on this subject in the February, 1887, issue of this journal, that at Blue Hill "predictions are made before sunset (at this season, at 3 P. M.) for the weather of the twenty-four hours, commencing at midnight." He then gave the following table, showing the percentage of successful predictions compared with that obtained by the Signal Office. To these I have added a column, showing what per cent. could have been obtained by predicting *fair* every day.

1886.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Blue Hill P. M. Predictions for 24 hours from midnight.	84	81	80	78	77	77	79
Signal Service Indications for 24 hours from 7 A. M.	68	71	63	81	70	74	71
Fair predicted continuously.	74	61	67	71	67	55	66

During the first half of 1887 the Blue Hill predictions were made between 2 and 2:30 P. M. for the next day, beginning at midnight. During the latter half of the year they were made between 1:30 and 2 P. M., generally at 1:30 P. M. In the statements sent out from this observatory these predictions were first called 3 P. M. predictions, and later 2 P. M. predictions. Any statement to the contrary, appearing elsewhere, was due to a clerical error. The following table shows the percentage of success obtained during the year, and for January, 1888, compared with the Signal Service predictions which were published in the same afternoon newspapers, and also with the percentage which might have been obtained by predicting *fair* continuously.

1887.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.	Jan.	Mean.
Blue Hill 2 P. M. Predictions for 24 hours from midnight.	81	79	74	83	77	87	74	71	70	78	70	90	87	79
Signal Service 10 A. M. Indications for 24 hours from 3 P. M.	71	68	65	83	74	77	84	65	73	58	69	77	71	72
Fair predicted continuously.	61	46	61	57	71	80	71	74	80	81	77	58	58	67

All of the predictions were verified by the Blue Hill Observatory records, and a rain prediction was called verified when .01 inch or more of rain (or melted snow) fell at any time within the twenty-four hours predicted for; while a fair weather prediction was called verified if less than .01 inch fell; and *vice versa.* In obtaining the percentages for October and November, which were published in the Bulletin of the New England Meteorological Society, the Sunday predictions were omitted. In obtaining the percentages in the above table, the Sunday predictions were included. The January predictions were verified in accordance with rules given in Chief Signal Officer's Report, 1886.

I have never stated, as "Gan" seems to think, that it is easier to gain a high percentage of successful predictions during wet than during dry months. All I have said, is that in dry weather one is likely to predict rain oftener than it occurs, and will thus get a lower percentage of success than if he predicted fair every day. He may, however, at the same time obtain a high percentage of success. Thus, if rain occurs on only one day in a month, and rain is predicted on three days, he would obtain a high percentage of success, but not so high as if he predicted fair every day; and in accordance with "Gan's" views his predictions would be of no value.

The interval from May to December was one of the dryest on record at the Boston Signal Office, so that it does not seem probable that "Gan's" fair weather predictor will soon again have such a run of success.

In regard to Professor Hazen's predictions, which have been discussed in *Science*, I was decidedly of the opinion that he had

been defeated by 16 per cent.; and I can only conclude that "Gan" has gotten his figures mixed in his statement above.

Far from believing that predictions extended for thirty-four hours in advance, are of no value, as "Gan" concludes, I think that such predictions are the only ones that are of any great value. To tell the public when the sky is overcast with heavy, threatening clouds, or perhaps when rain is falling, that the *Indications* are, that it will rain, as the Signal Service sometimes does, seems to me of no value; for it has been repeatedly shown that persons with no meteorological knowledge, can make as successful weather predictions for a short while in advance as any weather bureau in the world, situated at a distance of several hundred miles from the area predicted for. Predictions become of value only when they are extended so far in advance, that to the average man they become a better guide to the coming weather, than the appearance of the sky and the conditions surrounding him. At Blue Hill flags are displayed every morning before eight o'clock, when there is thought to be indications of rain before midnight. When these flags are displayed, the only telegraphic data available is that from observations taken twenty-four hours before, so that the predictions are based mostly on local indications. These predictions for nearly two years have given an average success of about 90 per cent.; yet we consider them of so much less relative importance than the predictions of longer range, that we do not publish the per cent. of verification.

H. Helm Clayton.

Blue Hill Observatory, February 4, 1888.

CURRENT NOTES.

A Draper's Thermograph has been purchased by the Michigan State Board of Health, and has been put to work at Lansing, where, as was to be expected, it is giving excellent satisfaction.

City Air.—Sir Douglas Galtan, referring to Dr. Russell's experiments carried out for the Meteorological Council, showed that rain water in London contained twice ss much impurity as

that collected in the suburbs. He also referred to Lodge's experiment of clearing a bell jar of smoke by electrical discharges, and argued that by disturbing the electrical condition of the air rain may be produced.—*Nature*, December 29, 1887.

A. L. R.

Action of Frost on Rocks.—Blümke puts cubes of various kinds of stones in distilled water under the receiver of an air pump, and after the air was exhausted and the cubes saturated with the liquid, exposed them to a freezing mixture. He finds that the material is the more resistant the less the weight of the particles it loses in a given number of freezings. Besides the well-known phenomenon of weathering, there is even in the action of frost a loss of extremely fine particles not perceptible in the material itself. The visible phenomenon may appear sooner the more water the stone has taken up.—*Nature*, December 29, 1887. A. L. R.

The Buys-Ballot Medal.—The writer has received a copy in bronze of the gold medal presented to Prof. Dr. Buys-Ballot, the famous Dutch meteorologist, on the 16th of November last, at Utrecht. The medal is about two and a half inches in diameter, and bears on one side, in relief, the head of the distinguished recipient; on the other the inscription of its award to him for forty years of academical work between the dates 1847 and 1887. A subscription was opened for this testimonial, and each ten years the Buys-Ballot medal will be awarded by the Royal Academy of Sciences of Amsterdam to the person, native or foreign, who shall have distinguished himself the most in meteorological science. A. L. R.

Dr. Hinrichs.—It is with great regret that we learn that the war against Dr. Hinrichs, to which we alluded nearly two years ago (Vol. II, p. 536), has now reached the stage of an attack on the weather service which he organized, and which he has now carried on for some twelve years, with great success, and at very little expense to the state. A bill has recently been intro-

duced into the Iowa Senate repealing the law establishing the service and abolishing the office of the director. At this distance the bill appears to be of the sort which is purely personal. This kind of legislation is dangerous enough when it is for the benefit of some popular favorite, but it becomes highly pernicious when it is used as a means of personal malice, as appears to be the case here. We can not believe that the great and flourishing state of Iowa would lend itself to such an object.

Dr. Hinrichs deserves not only considerate but grateful treatment at the hands of the people of Iowa. He has brought his weather service to a high state of perfection, and has made the climate of Iowa one of the best known climates in the United States. The last biennial report of the service is full of information, and is worth much more to the state than all the weather service has ever cost. The paper of Dr. Hinrichs, which we publish in this number, will save the pomoculturists of the state from years of experimentation. The present director of the weather service has not only placed his own services gratuitously at the disposal of the state, but he has also brought to the work talents and training which are very rare. If the state consults its bests interests, it will not only not abolish the service but will give its director so large an appropriation that he can be free from other cares and devote himself exclusively to its development.

REPORTS OF AURORA BOREALIS.—Sept. 15. -British steamship "Coronilla," Capt. Gavin, reports in lat. 38° 30′ N., long. 71° W., at about 9 P. M., observed in the eastern horizon a bright illumination for about 8 seconds. Cloudy, light breeze, N. E.

Sept. 29.—British steamship "Catalonia," Capt. Wylie, reports in lat. 43° 11′ N., long. 63° 35′ W., saw northern lights very bright. Wind moderate, W. N. W.

Nov. 8.—Norwegian brig "Smut," Capt. Tonnessen, reports at 7 P. M., Highland Light, Cape Cod, W. by N. ½ N. 6 miles, observed a brilliant display of Northern Lights. An arc from N. N. W. to N. N. E. about 10 degrees long, with white columns

of light shooting to the zenith; shooting stars from S. W. to N. E. Barometer 29.48.

Nov. 18.—British steamship "Samaria," Capt. Watts, reports a brilliant display of Northern Lights in lat. 42° 50′ N., long. 65° 04′ W. Columns of light shooting up from the northern horizon.

Nov. 19.—British steamship "Cephalonia," Capt. Walker, reports in lat. 49° 44′ N., long. 31° 39′ W., a brilliant display in the northern horizon in the shape of a low arch, with columns of light shooting up to it from the horizon. Barometer (corrected) 30.198.

Nov. 21.—British steamship "Cephalonia," Capt. Walker, reports in lat. 46° 40′ N., long. 46° 24′ W., at 6:15 P. M., a brilliant display of aurora borealis, consisting of columns of light shooting up from the horizon. Barometer (corrected) 30.522.

The above reports are due to the kindness of Commander Bartlett, Hydrographer of the Bureau of Navigation.

METEOR REPORTS.—We owe the following reports to the kindness of Commander Bartlett, Hydrographer of the Bureau of Navigation, at Washington:

Sept. 15.—British steamship "Cephalonia," Capt. Walker, reports in lat. 42° 28′ N., long. 62° 22′, at 8:45 P. M., observed a brilliant meteor; sparks radiating from the centre; and a long, fiery tail. The meteor was seen to the E. N. E. falling to the N. E. The sky was brilliantly illuminated for the space of 6 seconds. It fell into the sea about half a mile from the ship.

Sept. 18.—British steamship "Cythia," Capt. Roberts, reports in lat. 47° 45′ N., long. 44° 04′ W., observed a meteor which fell from the clouds at an altitude of 15 degrees, falling in a northerly direction, and disappearing below the horizon.

Nov. 14.—Norwegian bark "Ruta," Capt. Sorenson, reports at 8 P. M. observed a brilliant meteor from the S. W. passing to the N. E. Time of flight, 2 minutes. Position of ship, Minot Ledge light abeam 3 miles.

Dec. 18.—Danish steamship "Island," Capt. Skjödt, reports from midnight to 4 A. M., in about lat. 54° 35′ N., long. 28° 42′ W.,

the heavens were constantly lighted with the aurora. There were flashes the whole night, but during the time mentioned it appeared almost as one continual glare. Wind W. and W. by N. with squalls. Barometer at midnight, 764.5; at 4 A. M., 767. Barometer (aneroid) 6.1 mm. high, 10 feet above sea.

Nov. 18.—British steamship "Flamborough," Capt. Fraser, reports in lat. 40° N., long. 71° 20′ W., at 7 P. M., a brilliant meteor appeared in the zenith, and moved rather slowly towards the west, leaving a long, bright tail behind it. Its brightness was such as to produce the same effect on the Captain as a remarkably brilliant flash of lightning, blinding him for a time, and causing him considerable pain in his head. Before the meteor the wind was fresh from W. S. W.; at the time of the meteor it fell light and shifted to west, and subsequently veered to W. N. W., increasing to strong breeze again.

Dec. 13.—Bark "C. G. Rice," Capt. Bailey, reports in lat. 40° 07′ N., long. 69° 42′ W., observed a brilliant meteor falling from the zenith to the east; flight, 5 seconds; disappeared at an altitude of 25 degrees. Very bright and emitting a great quantity of sparks; a long, fiery tail.

Jan. 25.—British steamship "Persian Monarch," Capt. Bristow, reports in lat. 44° 07′ N., long. 51° 05′ W., at 6 A. M., an electric mass or meteor fell from the sky and exploded close alongside the ship with a very vivid flash and loud report. It could be compared only to the report of a large cannon fired close alongside. Some of the sparks fell on deck. No thunder or lightning either before or after the occurrence. After the explosion the squalls were very heavy and thick. Wind at time blowing gale from W. by N.

MEETING OF THE NEW ENGLAND METEOROLOGICAL SOCIETY.—At the meeting of the New England Meteorological Society, on January 17, three interesting discussions were had.

Mr. Desmond Fitzgerald exhibited some thermometers made by Baudin, of Paris, one of which was specially designed for taking the temperature of water, and is used by the Department of Public Works in France. The scientific nature of Baudin's

work was pointed out and his workshop described. Mr. Fitzgerald gave a brief summary of the changes in temperature in the waters of a lake during the different seasons, and alluded to the formation of anchor ice in the reservoirs of the Boston water-works.

Mr. A. L. Rotch, the chief of the Blue Hill observatory staff, exhibited a new "aspiration thermometer," which he regarded as preferable for scientific purposes in being more accurate. The principle on which it operates is the determination of temperature of the air, not as it immediately surrounds the bulb of the thermometer, but by drawing a current of air from a short distance across the bulb. The new instrument is the device of Dr. Assmann, of Berlin. It is double, having both a wet and dry bulb, with an attachment for use in rain or sunshine, for protecting the bulbs and maintaining on their surfaces the normal temperature only.

Mr. Clayton, assistant at Blue Hill, exhibited and explained the new Swedish cloud mirror in use there. Certain advantages were recognized in it, particularly the darkening of the mirror by making it of glass slightly tinted. This permits and observation of small white clouds which, in the white mirror, might pass unnoticed.

On the whole, the speaker seemed to be better satisfied with the cloud mirror, which for some time past has been in use at the observatory, which was in part of the essayist's own devising. He gave diagrams on the blackboard to show how and why clouds near the horizon can be measured as to speed and direction by the American instrument without going through with a certain mathematical process for elimination of apparent error, which in the use of the foreign instrument is necessary.

Professor W. M. Davis, of Harvard College, exhibited and explained with commendation a new series of meteorological maps covering the whole globe, by Dr. Hann, of Vienna. Mr. Davis said:

The uses of these admirable charts are various. To the scientific investigator they have a value from representing the best that can be done with the data now gathered in the way of iso-

therms, isobars and other graphic results of meteorological observations in all parts of the world. Dr. Hann may certainly be depended upon as having all available material at hand, and a well-trained discrimination in its use. The results that he approves may be taken as foundation for further work. To the general student, looking for quotable information, the charts are precisely what he needs in the way of meteorology: the hottest, coldest, wettest, dryest regions may all be searched out and described in their proper relations. And to younger scholars, the charts have undoubtedly a high educational value.

Meteorology, as ordinarily presented in schools, does not give the scholar opportunity enough to learn his lessons properly; he is told and taught too much, and his right of discovery is infringed. The little charts in text-books are too small and are often too indistinct for easy use, as they are too few for complete study. Dr. Hann's charts, on the other hand, are large enough for class-work with ten or twenty scholars; they are admirably clear in outline and color; and they present a surprising amount of material in graphic form, ready for profitable examination by scholars of sixteen or more years of age. Consider for example the isobaric charts.

Before approaching them, the class should have made local barometric observations, and should have become familiar with the frequent baric changes shown on our daily weather maps; thus knowing something of local and actual observations, they can reasonably examine charts of world-wide averages. Look first at the mean pressure for the year, and let every member of the class write out his own statement of it in brief form: low pressure around the equator, high pressure just outside of the tropics, and lower pressure toward the poles. What does this mean? Can it be the effect of the earth's attraction or the centrifugal force of its rotation? A brief consideration will show that gravity, the resultant of these two forces, acting alone, could only produce equal atmospheric pressures all over the earth (at sea-level). Can it be ascribed to the effect of the strong sunshine at the equator as compared with that at the poles? The high equatorial temperatures, already familiar

from the isothermal charts, will cause an expansion of the atmosphere there, and a high-level overflow towards either pole; a return underflow will then be established, impelled by the increased polar pressure towards the equator, where the pressure is deficient. The difference of pressure between the warm and cold regions will thus be diminished: it will be reduced to and maintained at a value just sufficient to cause a steady convectional circulation under a steady supply of heat; in other words, the isobaric surfaces (whose position in vertical section can be nicely shown by a working model, in which movable wires represent the isobaric lines) will be arranged so as to give a gravitation acceleration just able to overcome friction. I need hardly say that this last condensed statement is at least a good two days' work for a class. If, then, difference of temperature, caused by difference of intensity of sunshine, is in turn the cause of the observed differences in mean pressure, we should expect to find low pressure at the poles, and high pressure at the equator, and a meridional return current from high to low latitudes. Is this the case? Again, in the charts for January and July, there should be low pressures where high temperatures occur and *vice versa*, with appropriate winds.

Is this true? The observant scholars will find much to examine on the maps in answer to these questions. Some facts will confirm the suggested hypothesis; others will seriously contradict it, notably the low pressure at the poles. Must it then be concluded that the hypothesis is entirely wrong, or is it correct as far as it goes, but insufficient and needing supplement. A suggestion, indicating the latter alternative, will be found in the peculiar habit that the winds have of turning aside from the gradients: give the class this hint and see what they make of it. Their effort at discovery, even if without success, will give a good foundation for full statement of the accepted explanation, and after this is digested, the pressure charts and the wind arrows should be studied anew. The wind arrows are unfortunately deficient over the greater part of the world, but over the Atlantic they are mapped in some detail, and in their disposition in the opposite seasons give most beautiful illustration

of the several controls that they obey. The winter hemisphere, in which the temperature gradient from equator to pole is greatest, is characterized by a continuity of the tropical belt of high pressure and the linear division between the trades and the westerlies: the summer hemisphere, where the extra-tropical lands shoulder off some of their warmed air, is characterized by a great tropical anticyclone in mid-ocean, with out-flowing spiral winds.

In all this, and in the many other lessons of the same kind, it is a great thing for the teacher to have so fine a set of charts as those of Dr. Hann's to refer to. They can be kept in sheets, unbound, and thirty shown singly or together to best advantage; their centesimal scales should be no drawback to their introduction; and their moderate price warrants their employment in many schools.

"Repertorium für Meteorologie," Band X. Edited by Professor Dr. Wild. St. Petersburg, 1887.

This tenth volume, of the most important series of Meteorological and Magnetic memoirs that is published, is not behind its predecessors in point of value. The biennial appearance of these volumes nearly always marks a progress in some branch of Meteorology or improvement in methods of investigating the Earth's Magnetism.

The table of contents of the present volume is as follows, (translated from the German):

No. 1. J. Mielberg.—On the absolute determination of the Horizontal Intensity of the Earth's Magnetism, 33 pages.

No. 2. R. Laurenty.—On the personal error in estimating the degree of cloudiness, 22 pages.

No. 3. P. Müller.—On the normal march (gang) and the disturbances of the earth's magnetic elements during the period of the Polar expeditions, August, 1882, to August, 1883, pages 48 + LXI.

No. 4. H. Wild.—New experiments on the determination of the true air temperature, pages 32.

No. 5. E. Leyst.—Investigation on Needle Inclinators, pages 133.

No. 6. A. Schönrock.—Thunder-storms in Russia in 1884, pages 32.

No. 7. A. V. Tillo.—Magnetic Horizontal Intensity in North Siberia, pages 8.

No. 8. P. Braunow.—Paths of Anti-Cyclones in Europe, pages 23.

No. 9. B. Ssresnewsky.—Paths of Cyclones in Russia for the years 1881 to 1883, pages 37.

No. 10. H. Wild.—Further investigations on the determination of the true air temperature, pages 24.

No. 11. E. Leyst.—Errors in the determination of the time of oscillation of magnets and its influence on absolute measures of the horizontal intensity of the earth's magnetism, pages 33.

No. 12. H. Wild.—Annual Report of the Central Physical Observatory for 1885 and 1886, pages 142.

Minor Communications:

I. K. Laurenty.—On the question of the apparent flattening of the vault of the sky, etc.

II. B. Ssresnewsky.—Simplified hypsometric tables.

III. R. Bergmann.—Weather observations on the Ishma, instituted by Diakonus Istomin.

Many charts and illustrations are to be found in the volume.

Passing over the separate papers, each of which deserves a special review, we will proceed to the annual report of Director Wild and make a note of some of the principal points of general interest.

Many changes occurred in the scientific staff of the observatory through promotions and resignations. A number of building improvements were made at the Pawlowsk Observatory.

At St. Petersburg comparative observations on rain-gauges were instituted. The more simple wooden protection (Holzzaunes) of the normal rain-gauge was found to give the same results as the more complicated Nipher funnel.

The Adie Anemograph was replaced by the Sprung-Fuess Anemograph, (for description see *Zeitschrift für Instrumentenkunde*, 1884, page 300, and *Meteorologischen Zeitschrift*, 1884, page 360).

Comparisons of thermometers were made at Pawlowsk, for the purpose of determining the true air temperature. At this last observatory a Richard Barograph (aneroid) Thermograph and Hygrograph were mounted to test their accuracy.

After a careful trial of the new thermograph of Negretti and

Zambra (in which a thermometer is inverted automatically each hour) for two years, from July 1, 1884, to July 1, 1886, the instrument was found to be unsatisfactory, and regular observations with it were discontinued. In 1885, 222 registrations were incorrect. The trouble seemed to be that the mercury thread broke at the wrong point, or else too much mercury would leave the bulb at inversion of the tube.

The photographic barograph was compared for four months with an ordinary mercurial barometer, and the average difference was $\pm$ 0.11$^{mm.}$ (max. dif. 0.4), which was just the same as for the Wild-Hassler barograph.

"The observations on atmospheric electricity were stopped on June 30, 1886, as, according to all past experience, the usefulness of the isolated measures is out of proportion to the pains spent in making them. When it becomes possible to get automatic registrations, then it will be worth while to resume the observations. This same remark holds good for observations of the earth currents."

Of the report on the observations of Earth's Magnetism we will not speak, as it is a subject almost totally neglected in America. Director Wild reports the comparison of the observatory standards of length and weight with the International standards at Sevres. (A full report to be given in the Bulletin of the St. Petersburg Academy).

On account of the tremors caused by the wagons passing in the street, it is only seldom that the normal barometer of the Central Physical Observatory can be used, and a similar instrument is to be mounted at the Pawlowsk Observatory (20 miles from the city), where observations can be made at all times. Improvements have been made in the arrangements for testing anemometers by means of the Combe's rotation apparatus.

Two new meteorological magnetic observatories of the first order have been founded, the one at Katherinenburg re-organized and placed under the directorship of Mr. A. Abels, and the other at Irkutsk, with Mr. Ed. Stelling as director. Both of these gentlemen have received a long and thorough training at

the St. Petersburg observatories, and are well known through their published work.

The Central Observatory has reporting to it, 199 land stations, 16 stations in the Tifflis Series, and 54 harbor and lighthouse stations.

In the division for Maritime meteorology and Storm warnings we find the usual European activity. Despatches from 53 foreign and more than 70 home stations are received daily, and 115 stations are published in the bulletin; and in the drawing of the synoptic charts about 130 stations are represented.

In 1886 an evening service was established, so that now predictions are made twice a day. Since 1885, there was introduced a new method of computing the percentage of success in the predictions. So that the marking corresponds more nearly to that of the English system. By this it was found that for 1885, 89 per cent., and for 1886, 84 per cent. were successful. The same predictions computed by the old method and based on more mathematical principles gave only 43 per cent. and 51 per cent. for the respective years.

In the Maritime division are 54 stations, located along the coasts of the numerous large bodies of water bordering on or lying in the Russian Empire.

Some 450 stations are provided with rain-gauges, and make observations for the Russian Service. The number of Thunderstorm stations is about 637 in 1886–7.

Professor Wild also gives considerable information in regard to the circumpolar observations and the work of the International Meteorological Committee.

The Appendices to the directors' report are always interesting, although brief. The present ones are: *a*, the mean daily rate of observatory clocks and chronometers; *b*, investigation of the success of storm predictions, list of Russian weather telegram stations, with reduction constant for barometer to sea-level, and list of foreign stations sending telegraphic reports; *c*, verification of tuning forks; *d*, list of publications by the officials of the Central Physical Observatory during 1885–6 (11 papers by Professor Wild and 25 papers by his assistants).

An unusually long report of Director Mielberg, of the Tifflis Observatory, is appended, consisting principally of details concerning instrumental constants and narrative of minor changes.

Of particular interest, however, are the first reports for the years 1885 and 1886, of Director Stelling, of the Irkutsk Observatory, and Director Abels of the Katharinenburg Observatory. There is given in a few pages the story of the founding of the new observatories and the net-work of stations secondary to them. This, with the account of the observations undertaken, deserves special mention at another time.

This giving directorial power to the younger men in charge of the observatories, shows the very liberal policy pursued by Director Wild in carrying on his scientific labors.

The remainder of the appendices contain the inspection reports, showing the condition and instrumental corrections. This knowledge adds greatly to the value of the observations to other meteorologists, as they can judge of the accuracy of the data. We have not space, however, to enter into the details of these reports.

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